Advancing the Behavior Modeling and Visualization of Entities in the Ground Vehicle Simulation Laboratory

Daniel W. Carruth, PhD
John McGinley
Chris Mikulski
Andrey Shvartsman

GVSETS

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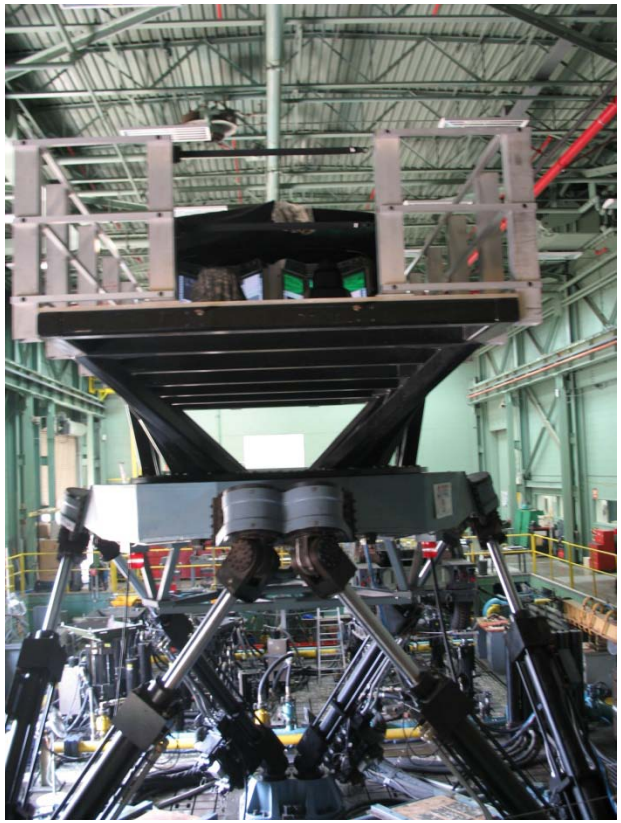
Introduction

- TARDEC Ground Vehicle Simulation Laboratory (GVSL)
  - Designs and executes soldier-in-the-loop distributed virtual simulations.
    - Goal: To Improve Army ground vehicle systems.
- Recent Experiments
  - Obtained physiological data on situational awareness decision-making. [1]
  - Created vehicle usage profiles (duty cycles) for hybrid electric combat vehicles. [2]

Introduction

- TARDEC and CAVS Simulators
  - Different hardware
  - Software parity



Introduction

- Subject Feedback from Experiments
  - Improve wandering behavior of human entities.
  - Develop behavior code for civilian interaction to map-based points of interest.
  - Improve red force human entity engagement response to blue force entities.
  - Improve human entity response to fire, ambush, and Improvised Explosive Device (IED) events.
  - Add animal entities to the virtual environment.

Introduction

- Simulation-based Reliability and Safety (SimBRS)
  - TARDEC GVSL partners with SimBRS researchers in Starkville, MS to address gaps.

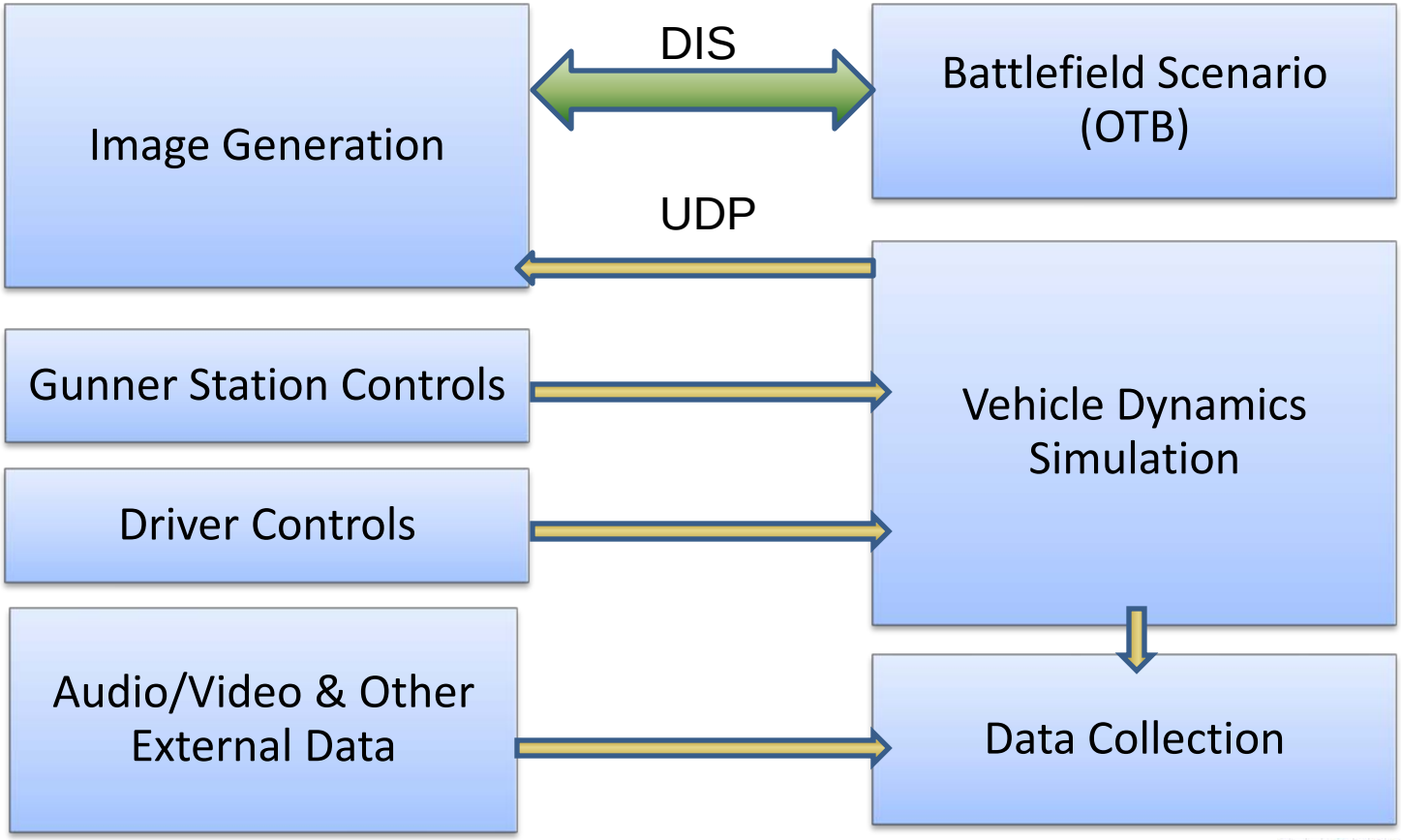
- Key Areas of Work
  - Record realistic motions using a motion capture system.
  - Generate animations to be implemented into TARDEC GVSL.
  - Develop behavior simulation code that shows improved adaptive behaviors for human entities.
  - Demonstrate animations and behaviors with a scenario.

Introduction

- Project Highlights
  - 2009:
    - Procedural pipeline developed to streamline animation process.
  - As of August 2010:
    - Human model motions have been collected, cleaned, and added to the simulation framework.
    - New Behavior: Civilian entities join a path at a point closest to their current location.

- Additions and modifications will improve the visualization and behavior modeling capability under TARDEC GVSL's current simulation framework.

Simulation Framework



Scenario

- Used to demonstrate new animations and behaviors.

- Convoy escort mission
  - 2 participants
    - Driver of the lead vehicle.
    - Controller of simulated CROWS station.
  - Red Force Ambush location
    - As blue force lead vehicle approaches location, an Improvised Explosive Device (IED) detonates in the road.
      - Civilians flee the scene.
      - Red force entities move in and begin firing on blue force vehicle.
      - CROWS station participant engages the red force entities, as the driver heads through the contact zone.

Human Entity Visualization

Human Entity Visualization

- Limited set of animations in character models
  - This constrains the ability to properly visualize human entity activities in the GVSL IG.

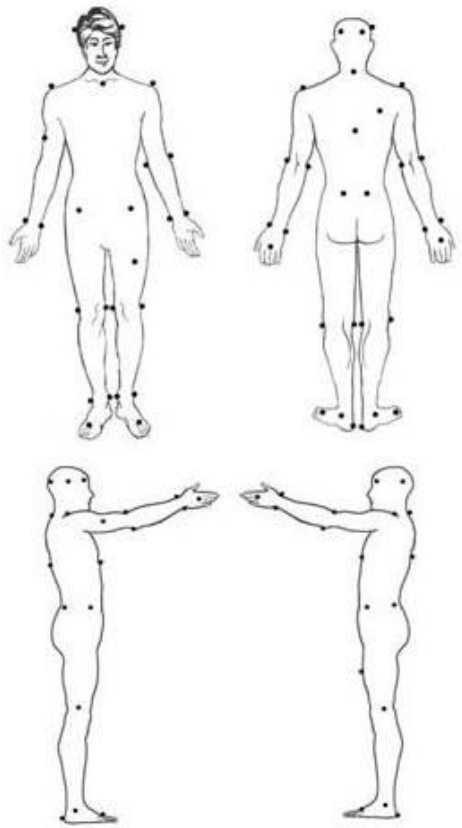
- To alleviate constraints, SimBRS researchers implemented an animation pipeline to generate animations compatible with existing character models using motion capture and commercial-off-the-shelf software.

Animation Generation

- Characters consist of 5 files types:
  - Configuration file
    - Describes how a collection of file represents a character.
  - Skeleton file
    - Defines hierarchical bone system describing the character's structure.
  - Animation files
    - Describes the animation of the character.
  - Mesh files
    - Describes 3D geometry representing the character's form and relationships between surface geometry and underlying skeleton.
  - Material files
    - Describes material and texture data for painting a surface of the geometry.

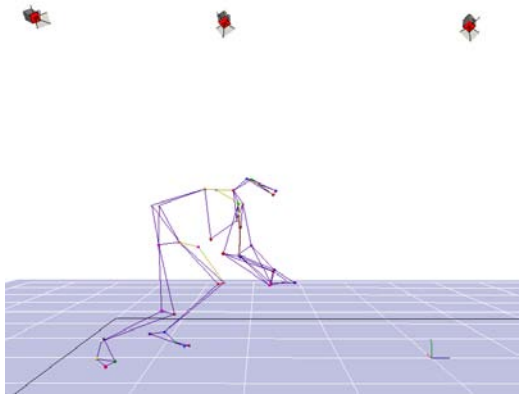
Animation Generation

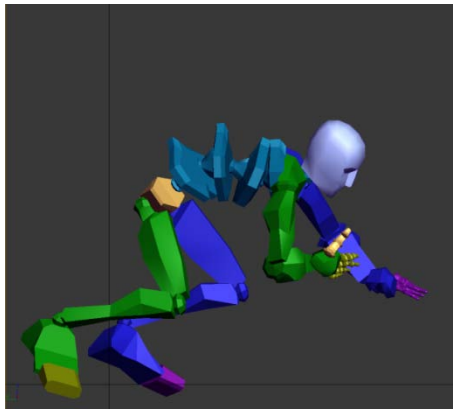
- Animations were collected using a custom marker set.
  - Actor was marked with 42 motion capture markers.
  - Generated 3D position data over time for each marker.



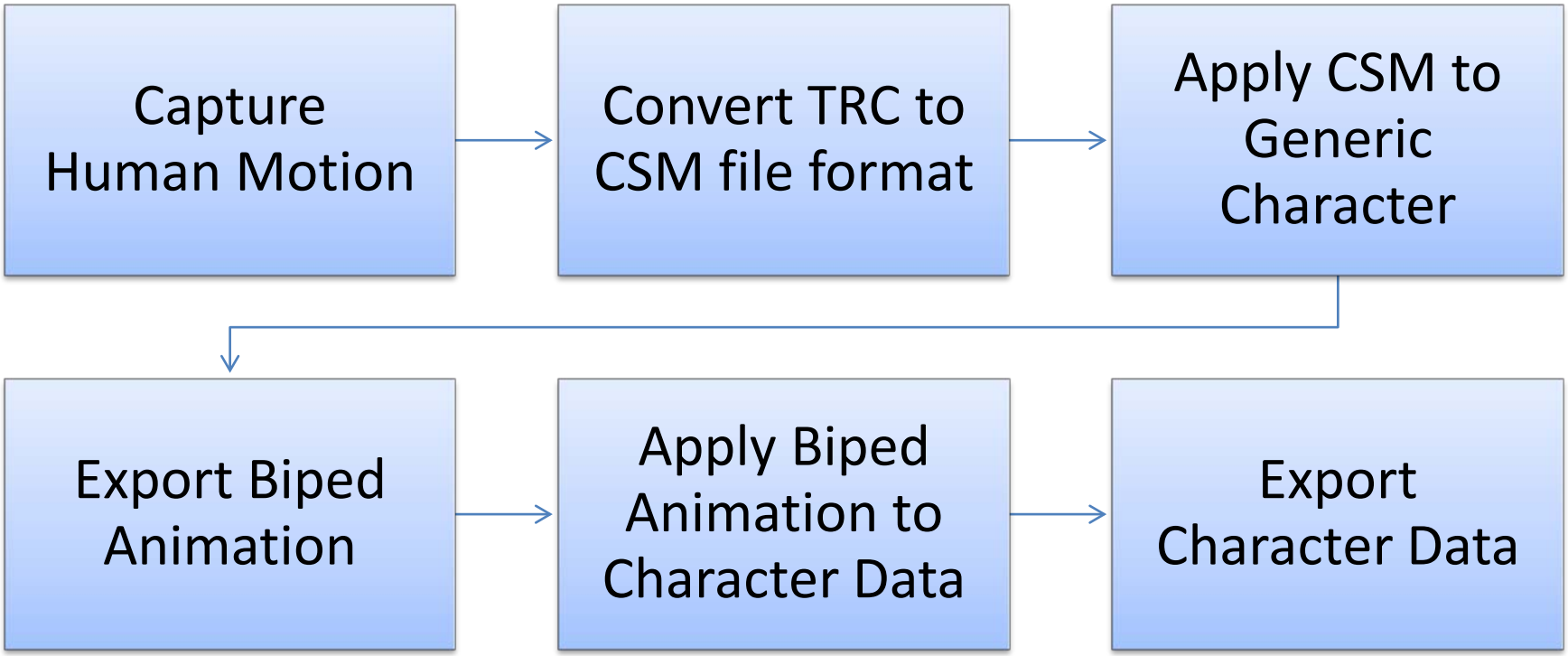
Animation Generation

- Cleaning Position Data
  - Visual noise and environmental objects obscured and created duplicate markers.
  - Automated and manual procedures were used to clean marker data.





Animation Generation



Animation Summary

Table 1: Animations Created for GVSL Characters.

Animation	*Type*	*Description*
Idle – Slow Shift	New	Entity stands in one location slowly shifting weight from one foot to the other.
Idle – Impatient	New	Entity stands in one location shifting weight from one foot to the other and occasionally tapping one foot.
Idle – Look at Watch	New	Entity looks at his/her watch.
Walk	Replacement	Basic walking gait.
Run	Replacement	Entity appears to be on a quick jog.
Limp	New	Entity limps on his/her right leg.
Crawl	New	Entity moves while remaining prone.
Firing Weapon while Standing	Replacement	Entity fires his/her weapon from a standing posture.
Firing Weapon while Kneeling	New	Entity fires his/her weapon from a kneeling posture.
Stand/Kneel Transitions	Transition	Entity kneels down and entity stands up.
Stand/Prone Transitions	Transition	Entity drops down into a prone position and stands up.
Hit by Gunfire	New	Upper body jerks in response to being hit by gunfire.
Fall Down	Replacement	Entity responds to being hit and falls down.
Dead	Replacement	Entity lays in the final position after falling down.
Kneel	Replacement	Static pose for kneeling. Replaced old kneeling static pose to match stand/kneel transitions.
Prone	Replacement	Static pose for prone posture. Replaced old prone animation to match stand/prone transitions.

Animation Variability

- If many entities initiate an animation, the playback in the IG will be synchronized in an immersion-breaking manner.

- Two Methods for Animation Variability
  - Multiple animations for a given task.
    - Breaks up repeating animations and creates apparent activity.
    - Example
      - Stand idle: depicts avatar shifting weight slowly from one foot to other.
      - Idle look at watch: depicts avatar looking at watch to determine time.
  - Pseudo-random start delays.
    - Creates an offset in the animation playback across two characters.

Animation Variability

Soldier models running after simultaneous start

Soldier models running with start delay offset

Height Variability

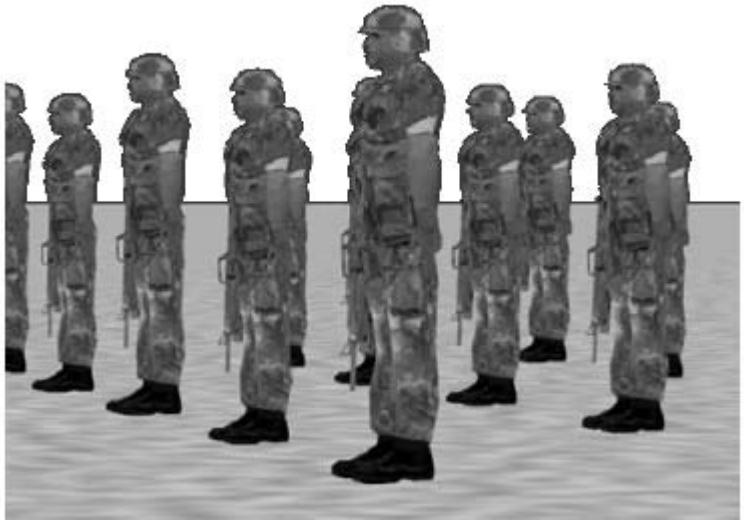
- When populating an environment with a limited set of digital human models, variation in height will be low.
  - One solution is to apply a scaling factor to the data representation of the entities.

- Human height is appropriately modeled using a normal distribution.
  - A Box-Muller transform can be applied to two linearly distributed pseudo-random numbers, U1 and U2, to generate a standard normal deviate.

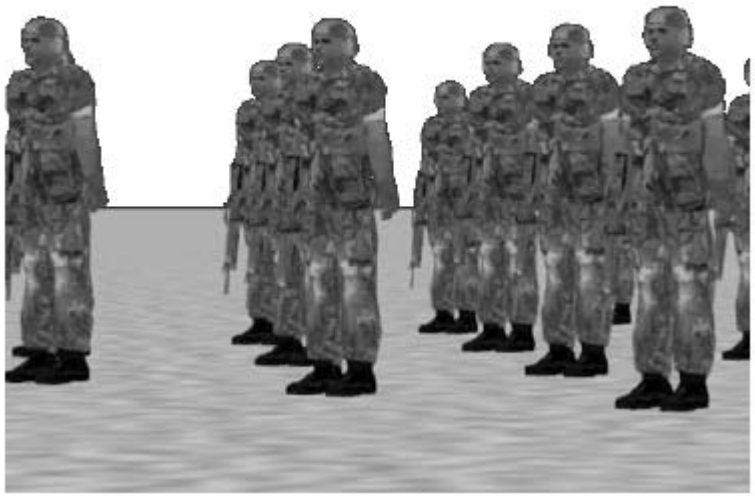
$$Z_0 = \sqrt{-2\ln U_1}\cos(2\pi U_2) \quad [3]$$

Height Variability

Uniformly Distributed Height Variability



Normally Distributed Height Variability



Human Entity Behavior Modeling

Behavior Modeling

- Identified gaps in available OTB behaviors.

- Move on Exact Path
  - Two Major Weaknesses
    - (1) Entities have limited awareness of events in the environment and do not react appropriately to combat-related events.
    - (2) Expects the entity to join the path at the beginning of the path.
  - Modifications
    - Corrected (2) by modifying task such that an entity, when assigned the task, would find the closest point along the path to its current position.
    - (1) will require combination of Move on Exact Path with additional behaviors.

Behavior Modeling

- Major Goals for Improvement
  - Make the behaviors of the civilian units more natural.
    - Exploring integration of task behaviors into an all-encompassing autonomous task behavior that would prioritize goals and react to changes in the environment.
  - Inferred behavior visualization technique
    - Standard PDUs cannot fully describe an entity's actions in the environment.
    - By considering the IG and other events in the simulation environment, we can attempt to infer the intent of the behavior and visualize a richer representation of the entity behavior.

Conclusion

- TARDEC GVSL requires immersive simulation environments to ensure subject performance will generate valid and accurate data.

- Subject feedback from previous experiments has revealed the need for improved visualization and behavior modeling of entities.

Conclusion

- Visualization
  - Implemented a pipeline for quickly generating new animations for existing character models from motion capture data.
  - Increased variability of character visualization through use of increased number of animations, variable character scale, and animation start offsets.
- Behavior Modeling
  - Improved capability to model ambient civilian traffic.
    - Modifications have reduced operator effort when defining paths and simplified the creation of paths for large numbers of entities.
- Efforts are underway to visualize context-dependent behaviors.

Thank you for your attention.

Any questions?

References

[1] V. Paul and K. Oie, “The Utility of Ride Motion Simulation in a Neuroergonomic Approach to Systems Design”, Proceedings of the 2009 Ground Vehicle Systems Engineering and Technology Symposium (GVSETS), 2009.

[2] M. Brudnak, M. Pozolo, A. Meldrum, T. Mortsfield, A. Shvartsman, W. Smith, J. Goodell, and D. Holtz, “Virtual Combat Vehicle Experimentation for Duty Cycle Measurement”, SAE World Congress & Exhibition, Detroit, MI, USA, Session: Military Vehicle Modeling and Simulation (Part 1 of 2), April 2008.

[3] G.E.P. Box and M.E. Muller, “A Note on the Generation of Random Normal Deviates”, The Annals of Mathematical Statistics, Vol. 29, No. 2, pp. 610-611, 1958.